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CALCARPOUS MARL IN PENNSYLVANIA SOUTH OF THE TERMINAL MORaine.

By

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Use in agriculture. Pennsylvania farmers spent in 1921 approximately \$2,000,000 for agricultural lime besides using large quantities of home burned and ground limestone. The cost of agricultural lime has nearly doubled in the last eight years and adequate liming frequently now is so costly as to be neglected at the expense of clover failure, reduced yields of other crops and soil exhaustion.

Within recent years many carloads of lime marl have been shipped into the State and sold for agricultural purposes. Most of this material comes from plants in West Virginia and Virginia where it is excavated with plows and scoops from large natural deposits, dried, screened and, in some cases, sacked for shipment. In spite of the high freight charges and relatively high price at which it has been sold to farmers this material has become rather popular. In analysis it compares favorably with other carbonate forms of lime such as ground limestone. The material is soft and generally rather fine in texture so that its action in correcting acidity is relatively prompt. Good results have been secured from the application of as little as 1000 pounds per acre, though up to 2000 pounds is generally advisable. On the other hand there seems little if any experimental grounds for the claims that marl is superior to other forms of lime or fine limestone carrying similar amounts of calcium, the only appreciable plant food which it contains being phosphoric acid, which seldom exceeds 0.5 per cent and consequently is negligible.

On account of the popularity of marl among farmers it seems opportune to call attention to the rather frequent occurrence of marl beds in the limestone regions of Pennsylvania. While most of the deposits are too small for commercial development they could be

utilized to excellent advantage as local sources of agricultural lime without the necessity for any expensive equipment, fuel for burning or power for grinding. Many similar beds are being worked by farmers in Maryland, West Virginia and Virginia and are supplying agricultural lime locally at very small expense.

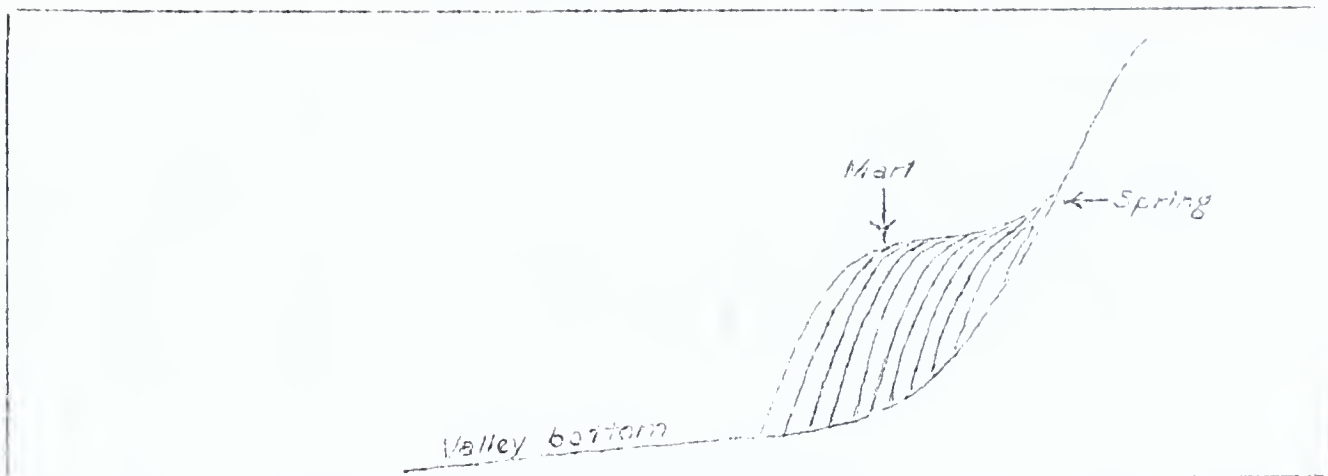
Chemical Composition. The marl herein discussed consists of calcium carbonate, small percentages of magnesium carbonate, and varying amounts of earthy and organic impurities which have been mixed with it during formation and subsequent reworking. The total carbonate frequently exceeds 90 per cent but in some reworked beds does not amount to more than 50 or 60 per cent. The average carbonate content on an air dry basis is between 80 and 90 per cent. The percentage of magnesium carbonate seems always to be low, ranging from 0.5 to 2 per cent.

Physical character. This marl seems to differ from that in the ponds and marshes of the glaciated regions in the manner of its formation. The latter no doubt owes its origin to the action of algal forms of plant life and frequently occurs in places remote from any limestone formations. The marl discussed in this paper, on the contrary, is always associated with limestone or at least found along streams rising from limestone springs. While the texture commonly is very fine, like the glacial marl, it may be more or less granular. Occasionally the marl forms concretions around some small object. Short, hollow tubes of marl occur, as if the mineral had been deposited around a stick or grass blade which had subsequently rotted out. Unlike the glacial marl which is generally too soft to drive upon after the surface soil is removed, the limestone marl is generally hard and dry enough to support the weight of horses. This marl not infrequently has consolidated or become cemented together locally, into rough, whiteish, horizontal slabs or concretions varying in size from a pebble up to large irregular boulders. This is most common where the marl is exposed. In many places where exposed, however, consolidation has not taken place.

Origin. A plausible theory for the formation of this marl is that the water from the large limestone springs, near which it invariably occurs, emerged heavily charged with carbon dioxide and calcium carbonate, much of it in the form of bicarbonate. On exposure to the air much of the carbon dioxide passed off as a gas. The water, having lost its carbon dioxide, could no longer carry so much calcium in solution and therefore precipitated it.

This method of formation is well illustrated by two deposits in the form of benches, one near Hancock, Maryland, and the other in Lawrence County, Pennsylvania. At the Maryland locality a small spring emerges from the limestone formation about 20 feet above stream level. A terrace of marl has been built out below the spring as shown in Fig. I. As the deposit increased in size the water from the spring apparently poured over all sides of it and continued to deposit marl until a terrace 100 feet or more in length was built. The deposit at Hancock has been dug into in development work so that the layers one above and extending beyond the other are plainly visible. The marl is more or less consolidated or crusted. Many of these layers show

Fig. 1



the impression of leaves, etc., over which the marl was deposited.

The deposit in Lawrence County is beneath a spring which emerges about 10 feet above the level of a stream. It is interesting, because it is one of the few deposits yet discovered west of the Allegheny Mountains, and further because the marl instead of being white is reddish brown in color, doubtless due to iron impurities. It is not as high in carbonate as the average, an analysis showing only about 65 per cent. Mixed with the loose brown marl are occasional rough, irregular, chunks of a very hard, fine grained, brownish limestone testing about 95 per cent carbonate and differing markedly from the rather soft, porous, coarse concretions found elsewhere.

Other deposits of marl occur as broad areas, such as those developed commercially in West Virginia. Some of these are slightly depressed, giving the impression that deposition took place in a shallow lake or marsh. In these cases evaporation and concentration of the lime-impregnated waters may have caused the precipitation. Frequently deposits along a good sized stream may be traced to a small spring coming in from the side higher up. There is generally a purer deposit close to the spring. Small pockets of marl sometimes occur along drainage lines quite high up on hillsides and in some cases the spring which formed a deposit has found another outlet or ceased to flow. The shells of land snails are often present in such numbers around these marl deposits as to lead to the popular but erroneous impression that the marl was due to the accumulation of shells.

Where found. As most commonly found the marl occupies flat areas or small bottoms along streams. In such situations it is generally covered by 6 to 12 inches of dark brown or black surface soil. Sometimes this overlying material is somewhat mucky but more often it consists largely of fine mineral matter washed in and deposited, no doubt mixed with the insoluble portions of the original marl. Occasionally the surface covering is so thin that the ash-colored marl is turned up in plowing. The covering is entirely lacking in some places, leaving the granular or ashy marl exposed. Unless the water table is quite high the soil overlying the marl is generally very droughty, due to the rapidity with which the water drains away through the marl. On account of the good drainage and



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consequent early production of crops, marl beds frequently are favorite locations for truck gardens.

As may be expected marl deposits vary widely in extent and depth. At Shooks Mill, $1\frac{1}{2}$ miles northwest of Greencastle, a deposit at least 20 feet deep is exposed where the stream has cut through it. Generally, however, the depth of deposits is not over 5 or 10 feet, frequently less. In some cases the marl may occupy rather extensive flats and may extend continuously or intermittently along streams for several miles, a part of it at least being eroded from the original location and redeposited. These broad deposits may have been built up by successive layers as illustrated in figures 2 and 3.

Fig. 2.

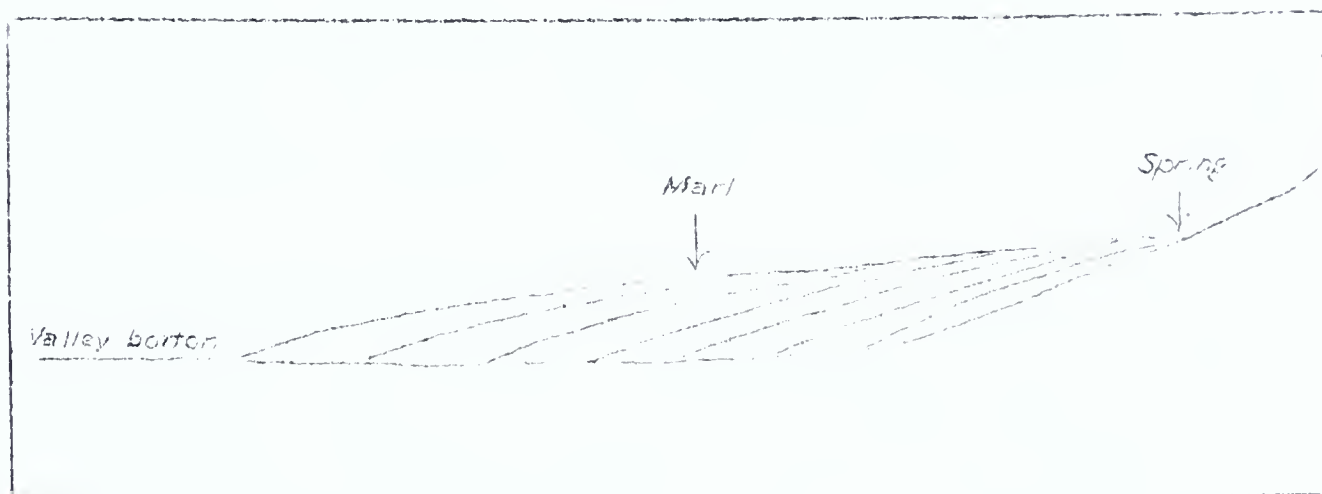
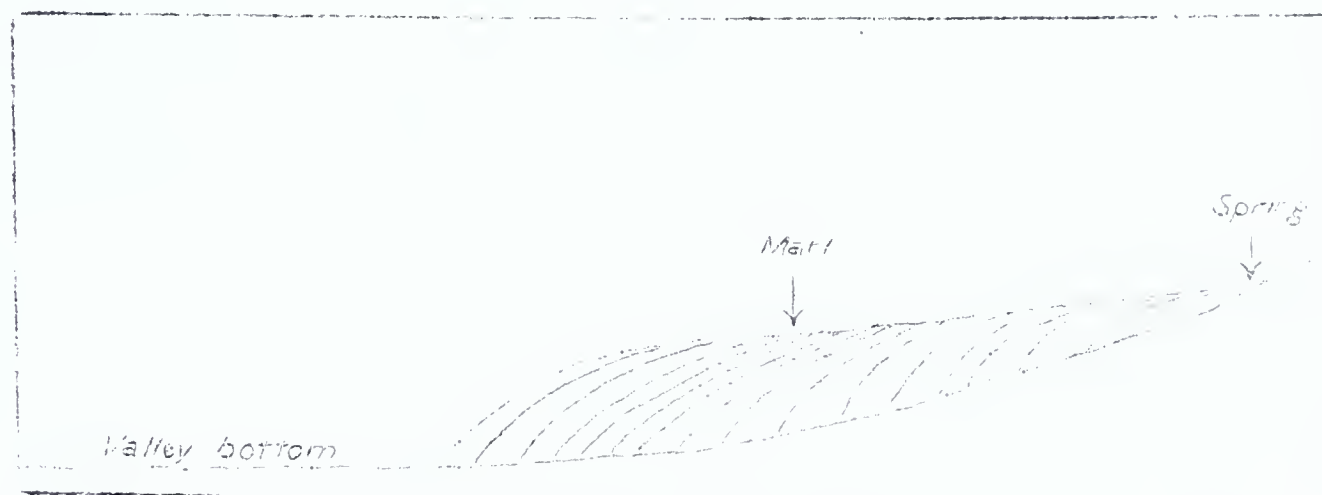


Fig. 3.



The marl here described always occurs along streams rising from limestone formations and is generally found close to their source. It may occur in pockets, narrow bottoms, or broad areas either low-lying or well above the present level of streams. On account of the soil covering it is generally noticed in stream banks and gullies or in the gray or ashy white material turned up in plowing or in digging ditches or post holes. The rough, white or yellow stained concretions above referred to may lead to its discovery, though these may be carried down stream some distance from the parent material.

White clay or sand is sometimes mistaken for marl. Suspected material may be tested with a few drops of hydrochloric or sulphuric acid. Violent bubbling indicates the presence of carbonate of lime either in the form of marl or true limestone. Samples may be sent to State College, or to the Department of Agriculture, Harrisburg, Pa., for analysis. Farmers may have excellent deposits of marl without suspecting their nature or value. One of the finest deposits located so far, in a section greatly in need of lime, was used only as a convenient place to bury dead stock on account of the ease with which it could be excavated.

In the better farmed sections of Pennsylvania, such as the Cumberland Valley, most of the marl is in localities where lime has been burned and applied liberally to the surrounding limestone land. Consequently the marl is here of less immediate economic importance. The deposits in Fulton, Huntingdon and Centre counties, however, are located where much less lime has been used recently and consequently the need for lime is pressing.

Development and Use. In order to be of commercial value or importance a deposit of marl must analyze 85 to 95 per cent calcium carbonate, must be of considerable size, fairly fine in texture and comparatively free from concretions. It should be at least fairly dry and so located as to be easily excavated without interference of surface water, and should be situated close to a railway or to good roads over which it could be trucked to consumers. Marl must compete directly with agricultural ground limestone, the present price of which in bulk is \$2.50 to \$4.00 per ton at the point of manufacture. In order to compete commercially the marl must be at least air dry and screened or ground so that it can be applied by machinery. Any great expense involved in excavating, preparing or transporting to the user or to a shipping point would be prohibitive. So far no deposits of commercial size or possibilities have been found adjacent to a railway in Pennsylvania. Some might be developed by a system of truck delivery direct to the users.

For local use, however, extreme dryness, fineness and size of deposit are not so essential, and if applications are liberal, material of lower grade may be used with equal results. The simplest method of development and use is to throw aside the top soil and the larger concretions, shovel the marl without drying or screening onto wagons, and draw it to nearby fields or farms where it is spread with a shovel from the wagon at the rate of 4 to 10 tons per acre. The rate of application should depend on the percentage of moisture, the fineness of the marl, the distance hauled and the cost at the pit. While heavy applications may seem laborious and expensive the coarser particles and smaller concretions will weather down gradually and maintain the soil in a desirably neutral or alkaline condition for the period of several crop rotations. Where the marl is low lying the moisture may reach 50 per cent, necessitating the handling and transporting of large quantities of water. Where handled in the above manner the price charged at the pit must be low, generally running from 50¢ to \$1.25 per load, depending on quality and moisture.

A more satisfactory method of handling deposits, especially those of some size and of good quality, is for the owner to strip the surface soil from a considerable area with plows and scoops or scrapers. The marl is then plowed up and allowed to sun dry as much as possible, the drying being sometimes aided by stirring with a harrow. When dry, the marl is loaded and hauled away by the purchasers or sometimes scooped into a shed by the owner for later sale. Since most of the marl is wanted during August, sun drying will reduce the moisture content sufficiently. The dry marl generally falls to a loose incoherent mass which is easily spread and in some cases it is sufficiently free from hard material to be applied with a spreader. The price asked for the sun-dried marl is from \$1.25 to \$2.50 per ton. Sometimes the dried marl is shoveled over a screen so that it can be used in drills.

At Jone's Spring, Jefferson County, West Virginia, a rather extensive bed of marl has been developed along the above lines and has gained considerable local popularity, some farmers hauling the material in wagons 15 or 20 miles. At this place the owner has also installed an old clay disintegrator operated by a farm tractor. The sun-dried marl is dumped into the hopper of the disintegrator with mule scoops; the pulverized material is elevated onto a jolt screen. The fine material passing through the screen is stored in a shed and sold for \$3 per ton. That which does not pass the screen is returned to the mill. The capacity of this outfit is said to be about 75 tons per day. The dried, unground marl is sold for \$1.25 per ton. The above plan seems nearly ideal for local operations. The price is low enough and the quality and condition of the material good enough to make it popular and with a sufficient output the enterprise should be profitable to the operator. If a system of truck delivery could be arranged, charging a rate of 15¢ to 20¢ per ton mile hauled, as is being done by limestone plants, the output and the territory covered could be increased and the period of operation lengthened. Farmers will seldom haul such material until ready to apply it; consequently unless there is ample storage the output is limited.

Some owners of marl deposits put the price too high to be attractive, or else feel that it is necessary to install expensive machinery for drying, grinding, screening and sacking. The investment would be too large for the size of the output unless the price per ton is too high to secure ready and extensive sales. With a few months of good drying weather in summer all that is necessary to produce a satisfactory product is a small hammer mill, with rather coarse grate bars, a $\frac{1}{4}$ -inch mesh screen, elevator and storage house; the latter preferably arranged so that the finished product can be delivered to wagons by gravity. Sacking should not be necessary for local trade, although the purchaser may bring bags and sack it himself if he wishes.

Description of Deposits: Cumberland County. Just east of Middlesex, three miles northeast of Carlisle, on the farm of Mr. W. R. Simons, on south side of pike and on east side of small stream for some distance and extending back into one or more depressions in fields is a deposit, sample of which showed about 85 per cent

carbonate (air dry). The texture is fine and color white. Deposit is well covered with surface soil; depth could not be ascertained with 40-inch soil auger. The deposit was not fully explored or traced.

On north side of pike opposite the above is a terrace about 20 feet above Conodoguinet Creek which seems to be composed of coarsely granular marl to an undetermined depth. Along the stream marl is solidified, but a short distance back from the bank the material is loose and granular. Deposit more or less reworked; yellowish gray below the surface soil. No samples taken. This terrace, several acres in extent, is occupied by a truck garden.

On eastern edge of Carlisle on the east side of a small stream (Letort Spring Run) are several acres of marl covered with 6 to 10 inches of dark soil. The bottom of the marl was not reached with a 40-inch auger. Sample tested 84 per cent carbonate (air dry). This deposit is close to railroad and might be developed but it is very little above the level of the stream. On account of the location the land would be held at a high price. Now occupied by truck garden. Origin of this deposit and its full extent not determined.

On farm of Daniel Witmer, about one mile south of Carlisle is a deposit of marl in a depression across the P. & R. tracks from Letort Spring Run. This is also the same which passes east of Middlesex to join the Conodoguinet, so that all these deposits may come from one source, though examination of the bottom land at several intermediate points showed no marl. The full extent of this last deposit may not be known but it did not seem to cover more than a half acre. The depth was over three feet. Sample tested was very white and fine. Practically all of it passed a 60-mesh screen and 90 per cent passed 100 mesh. Analysis shows over 95 per cent total carbonate. This is the purest and finest sample of marl examined. The deposit has never been utilized and is probably too small for commercial development. It could be utilized locally, however, until the water became troublesome as the excavation deepened. The water table is rather high.

On the Harvey Line farm and adjoining property three miles west of Carlisle marl occurs in a bottom along a small stream. Bottom used largely as pasture and covered with 6 to 8 inches of brown soil. Depth of marl over 3 feet; air dry sample carried 84 per cent lime. Water table rather high but marl could be developed for local use.

On the Lehman farm, $\frac{1}{2}$ mile northeast of the above deposit, marl occurs along the stream. The surface soil has been eroded from this deposit in places. Its extent and analysis were not determined.

On the farm of W. McKeehan, one mile south of Alterton, west of Carlisle, is a considerable body of marl occupying a depressed area. Sample analyzed only 48 per cent total carbonate. Sample from Andrews' farm adjoining tested only 51 per cent. These samples were low in lime but the marl was easily accessible, fine in texture and comparatively dry so might be used economically on nearby fields.

Franklin County. Back of mills in Chambersburg, Falling Spring Branch cascades over a considerable body of consolidated marl the extent of which could not well be determined. The marl is discolored to a brownish yellow.

About $1\frac{1}{2}$ miles east of Chambersburg where the above stream crosses the Lincoln Highway is a deposit of rather granular and more or less reworked marl on the north side of road. Deposit here is rather small but marl is said to occur in several places along this stream toward Chambersburg.

On farm of Mr. Bruce Lehman, about 2 miles southwest of Waynesboro, a deposit of marl covering about 15 acres occurs in a bottom along one side of which flows a small stream. The deposit is covered with 6 to 10 inches of dark gray, rather heavy soil. The marl was rather dark gray in color and inclined to be sticky. At one point where some had been dug out, cemented chunks or slabs were encountered. The depth of the marl could not be determined with a 40-inch auger. Samples tested 73 to 84 per cent carbonate in a barely air dry condition. A previous report on this deposit gives analysis of 90 per cent carbonate and a depth in places of 18 feet. This is one of the largest deposits so far encountered but is too far from a railroad for commercial development.

On the farm of Ellis Kuhns, about 2 miles southeast of Greencastle, a deposit of marl is reported but has not been investigated.

On the farm of Mr. U. G. Shook, about 2 miles west of Greencastle, just south of the Mercersburg road, is a large, promising and interesting deposit. A stream rises below the house and crosses the road at a mill. Marl is exposed at the road crossing and extending down back of the mill for some distance. The stream below the road falls 25 or 30 feet, and at one point has cut a straight bank down through marl for 20 feet. The marl is largely uncovered and is used for a truck patch beside the mill. In texture it varies from granular on the surface to finer below. In analysis it showed 85 to 90 per cent carbonate. On account of the deep stream channel this deposit is exceptionally well drained. It is easily accessible from the road, requires no stripping of surface soil and seems to contain no coarse material. It is too far from a railroad for commercial development and is located in a section where lime has been used liberally and the present need is not great.

Mr. Ed. Hess at Brown's Mills about 3 miles northeast of Greencastle, has a deposit of marl in a field across the road from an old stone mill. This deposit forms a terrace 8 or 10 feet above the stream. The marl is covered with brown surface soil on top of the terrace, but shows in washes on the slope. It does not seem to occur on lower level; probably having been eroded off. This marl is rather granular and carries 80 to 90 per cent carbonate. The deposit covers several acres, is well drained and could be easily developed to supply local needs.

Fulton County. The only known deposit in Fulton county is on the farm of Mr. Job C. Hess, about 4 miles north of Warfordsburg, in

a small limestone cove. The deposit covers about $\frac{1}{2}$ acre near Mr. Hess' house. It was no doubt formed by a spring which rises just above and which has been piped to the house so that the deposit is now well drained. It lies in a sort of picket, well above the level of the nearby drainage. The color is almost pure white and samples are reported to analyze as high as 93 per cent lime. The deposit is covered with a few inches of dark surface soil. Depth of the deposit was not determined but is over 5 feet.

Mr. Hess has developed this deposit in a small way during recent years. The marl is scooped out in dry weather, screened and sold at \$3 per ton or 13.5¢ per bushel. A bushel, air dry, weighs about 90 pounds, and since the moisture varies it is fairer to the purchaser to sell by measure than by weight. About 100 tons were sold from this deposit in the fall of 1921. Applications were often made with a grain drill as light as 1000 pounds per acre or less and results on wheat and clover were reported very satisfactory. Applications on the home farm were heavier and results consequently better.

This deposit has special value because it is in a section too far from a railroad for commercial lime to be available, and where there is no coal with which to burn lime.

Huntingdon County. On the farm of Mr. Cummings, $\frac{1}{4}$ mile east of McAlevys Fort, occurs a deposit of marl along both sides of a small stream. The deposit no doubt originates from a spring which comes in from the side and which is now piped off to supply a farmhouse. The marl extends down the stream for about 100 yards onto the adjoining farm of Mr. Bigelow. When first discovered as exposed in the banks of the stream the deposit was only 2 to 3 feet in depth. In the course of development the depth of the marl farther from the stream increased to 4 or 5 feet. The width of the deposit varies and is not over 150 feet at any point.

The marl here is yellowish gray in color, inclined to be granular and to contain considerable quantities of rounded, pebbly concretions and large irregular cementations.

The surface covering is about 6 inches of brown soil and the marl rests on the native limestone and shale. At some points a layer of black, carbonaceous material 2 to 3 inches thick occurs about the middle of the deposit. This is apparently a mucky organic deposit. The lime in the marl varies from 80 per cent for the finer material to 95 per cent for the purer concretions.

This deposit was discovered by the County Farm Bureau Agent and the Extension Specialist in 1919. Its value was explained to the farmers and several hundred tons have been dug out and applied with good results. Applications are made with a shovel and probably average four tons per acre. The owners have received \$1 to \$1.25 per load, which for the rather coarse and undried marl is rather a high price.

On the farm of William Bair, 2 miles east of McAlevys Fort, occurs an excellent deposit of very fine textured marl, free from

concretions and analyzing, air dry, about 85 to 90 per cent CaCO_3 . The deposit starts just below a spring and extends along the spring drain for about $\frac{1}{4}$ mile, with a width seldom over 50 feet. At one point where the stream has eroded a channel, 6 to 8 feet of marl is exposed with very little surface covering. This marl is ashy gray in color and loose and friable in texture. When the value of the deposit was explained to the owner he made several small experimental applications, with good results. Farms in this neighborhood are in need of lime and this marl might be used if the price were reasonable.

Centre County. An excellent deposit of marl has been discovered on the farm of Mrs. John M. Otto, about 2 miles east of Spring Mills. The main deposit covers about $\frac{1}{2}$ acre to a depth of over four feet and extends from the main stream up a depression toward a small spring which no doubt is its source. The marl is gray, fine and free from coarse material and is covered with a few inches of loose, almost black surface soil. Analyses show a total carbonate content on an air dry basis of about 80 to 85 per cent.

Marl in a more or less reworked condition extends down the main stream for $\frac{1}{4}$ mile, largely on the farm of Mr. Gross Shook. This reworked material contains considerable clay, is more plastic and seldom analyzes over 70 per cent. Preparations are being made to utilize and sell the marl on Mrs. Otto's farm and that on the Shook place is satisfactory for home use though somewhat more impure and difficult of distribution. Little lime has been applied in this section for many years so that the marl will supply a decided soil need.

Lawrence County. On the farm of Mr. Andley Boak, New Castle, R. D. No. 6, on the Princeton-Harlansburg road, occurs a terrace formation of brown marl beneath a spring which emerges about 10 feet above the level of a stream. This marl analyzes about 60 to 65 per cent carbonate. Mr. Boak has used this marl on his own farm for a number of years with excellent satisfaction, hauling it directly from the bank and spreading from the wagon or heap at the rate of 6 to 8 loads per acre on land plowed for wheat.

Allegheny County. A deposit of fine textured, white marl analyzing over 90 per cent carbonate occurs on the farm of Stephen Bedner about 1 mile from Bridgeville. The deposit has not been inspected by the writer.

Westmoreland County. A sample of marl from the farm of E. E. Myers, North Alexander, was analyzed several years ago and showed 52 per cent total carbonate. The writer has not seen this deposit.

